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March 2013 | Volume **70** | Number **6**
Technology-Rich Learning Pages 22-27

Our Brains Extended

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Is the human brain still the smartest thing on the planet? When enhanced by technology, it is.

You think of technology as a tool," one high school student told me. "We think of it as a foundation; it underlies everything we do."

As this comment shows, like it or not, technology has become foundational to both education and life. Educators should think of technology in the same way they've long viewed reading—as a key to thinking about and knowing about the world. In fact, in the 21st century, technology is *the* key to thinking about and knowing about the world. Reading continues to be important—no one argues against teaching or learning it—but today, reading is no longer the number one skill students need to take from school to succeed.

Technology is.

A New Way of Thinking

The fact that many adults would dispute this statement illustrates how few understand the extent to which the world has changed in our kids' lifetimes, and the role technology now plays. Let me clarify: Technology isn't about new "stuff." It's not about laptops, iPads, cell phones, or the software kids use. It's not about different ways to do what we do now. And it's certainly not about what we should or shouldn't allow kids access to. All those ways of seeing technology are misleading.

Technology, rather, is an extension of our brains; it's a new way of thinking. It's the solution we humans have created to deal with our difficult new context of variability, uncertainty, complexity, and ambiguity. The human mind, as powerful as it is, is no longer powerful enough for our world; the old "tried and true" human capabilities just aren't enough. Technology provides us with the new and enhanced capabilities we need. So technology isn't something we need *in addition* to mental activity; technology is now *part* of mental activity. And we need to use it wisely.

Humans have always depended on external mind enhancements (writing, for example). Integrating these tools into our minds is not dependence in a negative sense; rather, it's closer to symbiosis. As professors Andy Clark and David Chalmers pointed out, "extended cognition is a core cognitive process, not an add-on extra."¹ According to Clark and Chalmers, the brain is continually integrating useful components it finds in the external world, such as our fingers for counting; pen and paper for writing; and, more recently, slide rules, calculators, and computers.

So when young people say, "When I lose my cell phone, I lose half my brain," they mean it literally. And they're right.

Rethinking the Curriculum

Wise integration of our evolving and powerful technology demands that we rethink our curriculum. What are the capabilities that make the human mind unique—such as empathy and passion—for which people should always be employed? What do machines do far better than humans—such as calculations and simulations—for which technology should be employed as much as possible? Now that kids are routinely exposed to increasingly sophisticated information online, what's an "age-appropriate" curriculum? What subject matter from the past is still relevant, and for whom?

In these digital times, is it still worthwhile to teach students how to write by hand, calculate in their heads, read, and define words and concepts—that is, most of the elementary school curriculum? Or is that like teaching kids how to hunt for their food? That was useful—once. We say we want kids to think, act, and relate effectively in their future. But many of the "new" Common Core State Standards serve only the needs of the 19th and 20th centuries.

Suppose we were to rethink our curriculum from zero, without any preconceived notions of what was important, caring only about students' future needs. In a world where you can point a scanner at any text and hear it read to you at any speed in any language, in an age when more and more ideas are distributed only on screens, do we still need to teach reading the way we do now? Or should we teach it using machines that can also read the words aloud and instantly link to related topics? In a world where machines can do calculations faster than any person ever could, do we still need the kind of math we currently teach? Or should we teach with tools like calculators and spreadsheets, which require students to focus on setting up the problem correctly, with the computation part done by the machine?

In a world where humans are becoming overwhelmed by volume, do students still need to practice composing long essays—or should they learn to powerfully condense their thoughts into pithy paragraphs and tweets? Far too many people still wrongly associate length with depth. One of my favorite challenges is to have students summarize in one sentence the essence of whatever book they're reading. Most can't do this—or can't do it well—because we don't emphasize conciseness. Although it certainly doesn't cover everything in the work, the tweet "*Romeo and Juliet* is an ironic, poetic, and emotional look at how misunderstandings and societal problems can turn innocent love into tragedy" reveals a depth of understanding. So can an excellent aphorism or haiku.

Technology-Enhanced Learning

As a powerful learning tool, technology enhances our capabilities in all domains. Not only can it help in surprising ways with things we still require from the past, such as test preparation, but it's also a *sine qua non* for many new capabilities, such as database usage.

Test Prep

Technology offers by far the surest way to increase scores on standardized tests. Who these days would take the SATs or ACTs without using a test-prep app?

Instead of guarding high-stakes state achievement tests as if they were state secrets until the day they're administered, why don't we use technology to ensure that all kids can get nearly perfect scores by permitting them to take the test *only* after they've mastered the app? Teachers would no longer have to "teach to the test" because technology can. Human teachers could offer, rather, what humans are best at: empathy, questioning, guidance, coaching, and encouragement. Test prep, if we need it, should be left to technology. If we're after higher PISA scores, why don't all 14-year-olds have a PISA app?

Database Usage

There are now millions of highly useful public databases, yet our students are rarely taught that they exist, much less how to find, combine, and use them. Much data that scientists, governments, and organizations collect are there for the asking. There are, courtesy of the CIA and the United Nations, huge publicly available databases of statistics on every country. These enable the kinds of animated analytics that Hans Rosling is now famous for (see "[Hans Rosling: Stats That Reshape Your Worldview](#).")

When my 2nd grader needs to know the meaning of a word, I tell him to use my iPhone to ask Siri, an artificial intelligence program that's always happy to look it up for him. Siri, in turn, uses the free online program Wolfram Alpha, one of the most powerful data analysis tools in the world. If you enter into the Siri (or Wolfram Alpha) search box, by text or voice, "arable land in world divided by world population," in less than a second the phone or computer will find the relevant data; do the calculations; provide the answer—in square miles, acres, square feet, and hectares per person—and cite you its sources.

Today, technology like this puts many college-level questions with definitive answers within the reach of 10-year-olds.

The technologies our students will be using in just a few years will be infinitely more powerful.

Technology as a Learning Tool

We need to start teaching our kids that technology is, in a great many cases, the *best* way to learn something. The best way to learn to solve real math problems is through technologies such as spreadsheets, calculators, and the software Mathematica, which force students to think about how to structure the problem. These technologies then do the calculations—the part that machines do best—enabling students to focus on whether the answer makes sense.

The only way to do almost all science today is with technology. No human can handle or analyze the volumes of data we now have and need. Ditto for the social sciences. The research study of the past focusing on 10 graduate students has been replaced by sample sizes of millions online around the world. Being perfect at language translation, spelling, and grammar is becoming less important for humans as machines begin to understand context and can access almost every translation ever done. Those who laugh at the mistakes that machines make today will no longer be laughing in a few short years.

Already, some of the best ways to study literature and theater involve technology—such as through videos, instant dictionaries, and shared commentaries and notes. I always carry with me (on my iPhone) all of Shakespeare and many other writers, dictionaries in multiple languages, thesauruses, books of quotations, videos of great actors reading important passages, and a huge collection of useful historical documents and maps. When I visit a new place, do I still need to find a bookstore to figure out what to do and see and get all the historical explanations? No, it's all on the phone in my pocket!

Moving from Trivial to Powerful

As we educators embrace these new capacities, it's important to understand that technology isn't just a "new way to do old things," which is mostly how we use it in schools today. That is, in fact, the most *trivial* use of technology. The only reason to use technology in that way is to make us more efficient and enable us to cut out something old to make room for new things we need. Anyone who maintains that we should continue to teach and use *both* the old ways and the new is suggesting that we maintain an expensive horse in the barn in case our car breaks down. This is unaffordably inefficient and just plain wrong. If our technology does break down temporarily (and everything does), we repair it and move on.

Technology's great boon to education, though, is that it enables students to do powerful new things that they *couldn't* do before. With YouTube, for example, students can post their ideas to the world and get rapid global feedback. With tools like Twitter and its cousins, they can follow firsthand details of events unfolding anywhere in the world, from revolutions to natural disasters. With mashups and related techniques, they can combine sophisticated data sources in powerful new ways. One school group I know of created a Second Life model of Los Angeles, using the database of the Federal Aviation Administration (FAA) to show each plane flying in its actual spot! With Skype-like tools, students can connect with experts and peers around the world in real time.

With sophisticated but easy-to-access simulations of everything from driving cars to running meetings, students can get immediate feedback on the implications of whatever strategies or actions they propose. Using virtual worlds, they can collaborate with groups large and small and solve problems in global teams. Using supercomputers (whose time we can now purchase by the second), students can run experiments millions of times over the span of human history.

I call the process of envisioning such technically enhanced possibilities *imag-u-cation*. It's something every teacher and class should spend some time doing.

But to make technology do all these powerful things, students need to learn to control it. That is, students need to learn how to program—not how to do the "nerdy" task of writing code that many fear, but rather how to make technology do precisely what we want it to. Controlling (that is, programming) our increasingly complex and powerful machines is one of the most fundamental skills that students ought to learn, starting in preschool. Because they realize this, many kids have already started to do this on their own, making playlists; filtering their messages; creating complex websites; doing sophisticated tasks on Facebook; modding (that is, modifying) games; and even teaching humanoid robots how to dance.

The New Curriculum

How could we rethink our K–12 curriculum for the 21st century, symbiotically combining human strengths with the most powerful technology strengths? We might begin by eliminating as *separate classes* all the subjects we now teach: math, English, science, social studies. All those subjects have become bloated and outdated and—far more important—are the wrong way to focus our kids' education in the 21st century.

K–12 study should focus on three crucial areas: Effective Thinking, which would include creative and critical thinking as well as portions of math, science, logic, persuasion, and even storytelling; Effective Action, which would include entrepreneurship, goal setting, planning, persistence, project management, and feedback; and Effective

Relationships, which would include emotional intelligence, teamwork, ethics, and more.

The remainder of this curriculum would focus on Effective Accomplishment—what you do with what you've learned. That part would be entirely project-based and real-world oriented and would differ for every student. It would include much of what we now call "content," but only what students would need to accomplish something real.

Subject 1: Effective Thinking

Effective Thinking would start in the early grades with simple mathematical and logical thinking and a focus on obvious flaws (such as assuming something is always true because you've seen a few examples). Young kids would use illustrative stories (like "The Emperor's New Clothes") and well-designed games (like The Logical Journey of the Zoombinis) as a basis for learning strategic and logical thinking. Technology would be introduced from the start as a "thinking extender" through tools like simulation that show students the consequences of their actions in a variety of contexts and circumstances. Even elementary kids would use spreadsheets and other analytics—many of them web-based—as parts of projects.

Students would learn from the earliest grades how to involve world databases, knowledge, sources, and teams in their thinking processes—for example, by creating and analyzing their own surveys of worldwide student opinion on current topics. As the years progress, students would learn about mindfulness; historical elements of human thinking (tool creation, logic, deduction, induction, calculus, and so on); dangerous flaws in human thinking (for example, Daniel Kahneman's exploration into the irrational ways we make decisions about risk); critical analysis; scientific thinking; mathematical thinking; systematic skills for problem solving; and ways to obtain self-knowledge of one's strengths and passions. Teachers would teach these skills, with both reading and technology as deep foundations.

How does this differ from what we do today? Instead of today's focus on pre-established subject matter, with thinking skills presented randomly, haphazardly, and inconsistently, the student and teacher focus would *always* be on thinking in its various forms and on being an effective thinker, using examples from math, science, social studies, and language arts.

Subject 2: Effective Action

Effective Action would begin by fostering Steven Covey's seven (now eight) habits of highly effective people—Be proactive, Begin with the end in mind, Put first things first, and so on—from the earliest grades. It would include increasingly complex challenges in persistence, entrepreneurship, and project management and focus on creative ways to break down barriers and get things done.

Students at all grade levels would learn how to start and manage real-life projects—for example, designing a playground, seeking funding, and getting it built; designing and implementing a better way to feed the local homeless population; or designing and implementing a day-care system—whatever the school's community needs.

Students would start companies, both for-profit (designing websites or devising social media strategies for local businesses) and not-for-profit (meeting a social need), and they would learn the difference between the two. The emphasis would be on continual improvement and on how to do each task more effectively next time. Again, students would use as "mind extenders" all the latest technological tools: simulations, CAD/CAM, and other software, as well as the best writing on project management.

The Effective Action curriculum would focus on getting students to be proactive, to initiate positive actions and programs to improve their communities, their country, and the world. Over the course of their K–12 time, students might explore and undertake such actions as mobilizing citizens for lobbying; building local Internet infrastructure; designing new schools and school additions; and, in places that need it, improving public health and the water supply. Instead of being occasional side projects in subject-oriented classes, learning how to do these types of projects—and actually doing them—would be the main focus of this portion of students' work.

Subject 3: Effective Relationships

Effective Relationships would foster students' high-level communication skills: one-on-one, in teams, in peer groups, in communities, and in work groups. It would focus on relationships in both the real and virtual worlds and teach students to negotiate a modern world in which both real and virtual are equally important. This subject would also include ethics, citizenship, and politics.

Over the course of their K–12 experience, students would learn how to maximize their own communication strengths and mitigate their weaknesses. They would learn how to best fit their own personality with all the communication possibilities offered in today's and tomorrow's world. Students would learn how to succeed in both the face-to-face world of visual prejudices and the online world of easy deception.

As a large part of Effective Relationships, students would read and analyze great works of literature that focus on human relations and relationships, study languages and translation, and explore material from the social studies. The focus of this subject would not be on producing people who *know* more, but on producing people who *relate* better in a wide variety of situations.

Culminating Work: Effective Accomplishment

Effective Accomplishment, taken every year by all students, would enable each one to establish a growing portfolio of completed individual and group projects. These would range from small projects in earlier years ("I made this app or this website") to larger projects ("I collaborated with a class in another country to publish a bilingual novel"; "I started a successful company") to participation in later years in huge, distributed projects around the world ("Using Galaxy Zoo, I discovered a new, habitable planet"). The focus would be on finding and executing real projects that extend the student's knowledge and capabilities in an area he or she is passionate about—projects that are helpful to the community and world. Thus, in addition to producing educated people, our schools would produce tangible and useful results.

Under this schema, what would become of the content areas that we teach today in linear fashion? Our students would still learn much of this content, but they'd learn it in a far different way: on an individual and "as needed" basis, as it became relevant to a project or to their interests. This would mean, of course, that every student's content knowledge would differ. Technology facilitates this in ways that were impossible in the past.

What all students would have in common, though, would be a strong, underlying, long-practiced skill set of thinking, acting, relating, and accomplishing, which, when they leave K–12, they could bring to more specialized higher education or work. This is a far more useful preparation for our students than the stovepipe system of "common standards" by subject we currently spend so much time creating and implementing. Already today, and certainly tomorrow, all knowledge and work are increasingly interdisciplinary and require a solid grounding, not in current content or standards-based skills, but in the underlying skills of thinking, acting, relating, and accomplishing.

Imagine if we evaluated students—and one another—on the basis of how effective each of us was at thinking, acting, relating, and accomplishing! Imagine a school structure designed to foster these skills in students instead of considering them as useful by-products of our content-based education and ignoring many of the most-needed ones, such as effective action and relationships.

What the Future Asks of Us

Producing effective letters, reports, and essays was an intellectual need of our past. Working effectively in virtual communities, communicating effectively through video, and controlling complex technologies are what students need to be successful in the future. Thinking, acting, relating, and accomplishing—in the technological and fast-changing context of the future—are where we should focus our students' attention.

"What's past is prologue," wrote Shakespeare. We must begin to think far more seriously about what our current education is prologue to—and whether that's now enough. No longer is the unenhanced brain the wisest thing on the planet. Students who don't have technology's powerful new capabilities at their command at every turn are not better 21st century humans but lesser ones.

Endnote

¹ Clark, A., & Chalmers, D. (1998). *The extended mind. Analysis*, 58, 10–23. Retrieved from <http://consc.net/papers/extended.html>.

[Marc Prensky](#) is the author of *Teaching Digital Natives: Partnering for Real Learning* (Corwin, 2010) and *Brain Gain: Technology and the Quest for Digital Wisdom* (Palgrave Macmillan, 2012).

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